

Markscheme

May 2021

Chemistry

Standard level

Paper 2

15 pages

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Subject Details: Chemistry standard level Paper 2 Markscheme

Candidates are required to answer **ALL** questions. Maximum total = [50 marks].

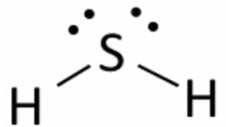
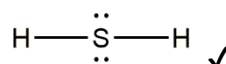
1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative word is indicated in the “Answers” column by a slash (/). Either word can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** *etc.* Either alternative can be accepted.
8. Words inside chevrons « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the “Notes” column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the “Notes” column.
16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the “Notes” column.
17. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the “Notes” column.

Question			Answers	Notes	Total
1.	a		mobile/delocalized <<sea of >> electrons		1
1.	b		<p><i>Any two of:</i></p> <p>forms acidic oxides «rather than basic oxides» ✓</p> <p>forms covalent/bonds compounds «with other non-metals» ✓</p> <p>forms anions «rather than cations» ✓</p> <p>behaves as an oxidizing agent «rather than a reducing agent» ✓</p>	<p><i>Award [1 max] for 2 correct non-chemical properties such as non-conductor, high ionisation energy, high electronegativity, low electron affinity if no marks for chemical properties are awarded.</i></p>	2
1.	c	i	<p>electrostatic attraction ✓</p> <p>between oppositely charged ions/between Fe²⁺ and S²⁻ ✓</p>		2
1.	c	ii	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ ✓	<i>Do not accept "[Ne] 3s² 3p⁶".</i>	1
1.	c	iii	«valence» electrons further from nucleus/extra electron shell/ electrons in third/3s/3p level «not second/2s/2p»✓	<i>Accept 2,8 (for O²⁻) and 2,8,8 (for S²⁻)</i>	1
1.	c	iv	<p>allows them to explain the properties of different compounds/substances</p> <p>OR</p> <p>enables them to generalise about substances</p> <p>OR</p> <p>enables them to make predictions ✓</p>	<i>Accept other valid answers.</i>	1

(continued...)

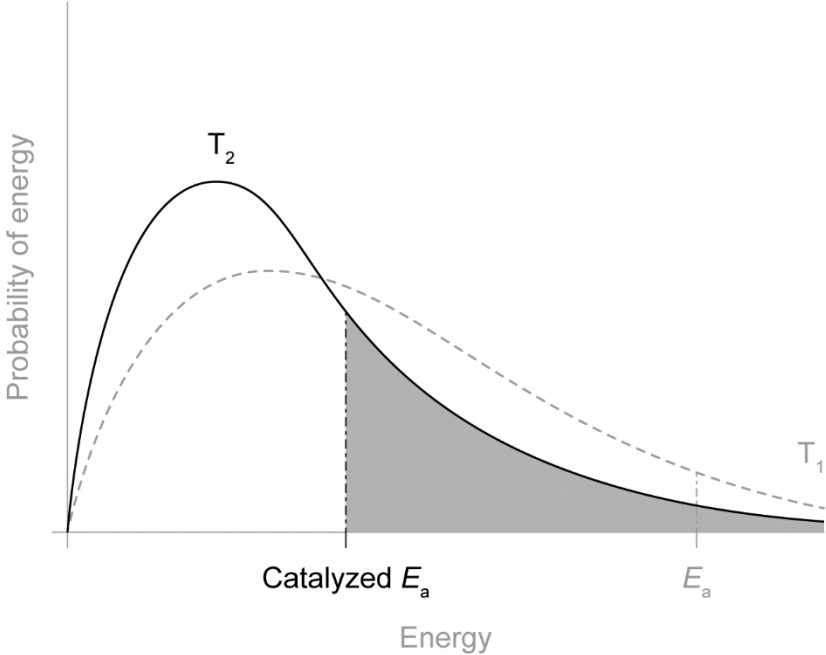
(Question 1 continued)

Question			Answers	Notes	Total
1.	d	i	$4\text{FeS(s)} + 7\text{O}_2\text{(g)} \rightarrow 2\text{Fe}_2\text{O}_3\text{(s)} + 4\text{SO}_2\text{(g)}$ ✓	Accept any correct ratio.	1
1.	d	ii	+6 OR -2 to +4 ✓	Accept "6/VI". Accept "-II, 4/IV". Do not accept 2- to 4+.	1
1.	d	iii	sulfur dioxide/SO ₂ causes acid rain ✓	Accept sulfur dioxide/SO ₂ /dust causes respiratory problems Do not accept just "causes respiratory problems" or "causes acid rain".	1
1.	e		disrupts the regular arrangement «of iron atoms/ions» OR carbon different size «to iron atoms/ions» ✓ prevents layers/atoms sliding over each other ✓		2

Question			Answers	Notes	Total
2.	a	i	 OR  ✓	Accept any combination of lines, dots or crosses to represent electrons.	1
2.	a	ii	bent/non-linear/angular/v-shaped ✓		1
2.	b	i	HS ⁻ ✓		1
2.	b	ii	weak AND strong acid of this concentration/[H ⁺] = 0.1 mol dm ⁻³ would have pH = 1 OR weak AND [H ⁺] = 10 ⁻⁴ < 0.1 «therefore only fraction of acid dissociated» ✓		1
2.	b	iii	10 ⁻¹⁰ «mol dm ⁻³ » ✓		1

Question		Answers	Notes	Total
2.	c	<p><i>Mole percentage H₂S:</i></p> <p>volume of H₂S = «550 – 525 = » 25 «cm³» ✓</p> <p>mol % H₂S = « $\frac{25 \text{ cm}^3}{550 \text{ cm}^3} \times 100 = \text{ » 4.5 «\%» ✓$</p> <p><i>Assumption:</i></p> <p>«both» gases behave as ideal gases ✓</p>	<p><i>Award [2] for correct final answer of 4.5 «\%»</i></p> <p><i>Accept “volume of gas α mol of gas”.</i></p> <p><i>Accept “reaction goes to completion”.</i></p> <p><i>Accept “nitrogen is insoluble/does not react with NaOH/only H₂S reacts with NaOH”.</i></p>	3

Question			Answers	Notes	Total																			
3.	a		1:2 ✓	Accept 2 Fe ³⁺ : 1 Fe ²⁺ Do not accept 2:1 only	1																			
3.	b	i	mass «spectroscopy»/MS ✓																					
3.	b	ii	<table border="1" style="width: 100%; text-align: center;"> <tr> <td></td> <td><i>Protons</i></td> <td></td> <td><i>Neutrons</i></td> <td></td> <td><i>Electrons</i></td> <td></td> </tr> <tr> <td></td> <td>26</td> <td rowspan="2">AND</td> <td>28</td> <td rowspan="2">AND</td> <td>26</td> <td>✓</td> </tr> <tr> <td></td> <td>26</td> <td>30</td> <td>23</td> <td>✓</td> </tr> </table>		<i>Protons</i>		<i>Neutrons</i>		<i>Electrons</i>			26	AND	28	AND	26	✓		26	30	23	✓	Award [1 max] for 4 correct values.	2
	<i>Protons</i>		<i>Neutrons</i>		<i>Electrons</i>																			
	26	AND	28	AND	26	✓																		
	26		30		23	✓																		
3.	c		specific heat capacity « $= \frac{q}{m \times \Delta T} / \frac{1000 \text{ J}}{50 \text{ g} \times 44 \text{ K}} = 0.45 \text{ «J g}^{-1} \text{ K}^{-1}\text{»} \checkmark$		1																			
3.	d	i	H ₂ O ₂ (aq) + 2H ⁺ (aq) + 2e ⁻ → 2H ₂ O(l) ✓		1																			
3.	d	ii	H ₂ O ₂ (aq) + 2H ⁺ (aq) + 2Fe ²⁺ (aq) → 2H ₂ O(l) + 2Fe ³⁺ (aq) ✓		1																			

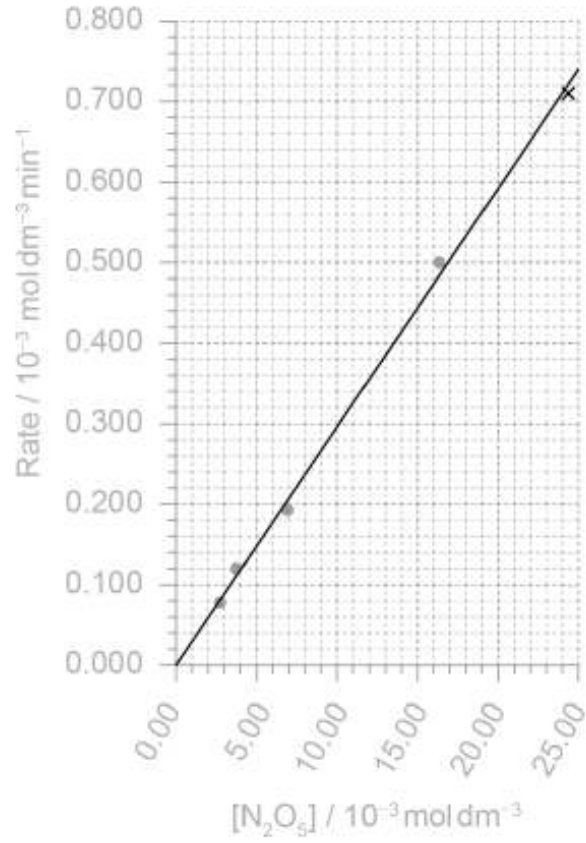
Question	Answers	Notes	Total
<p>4. a</p>	 <p>The graph plots 'Probability of energy' on the y-axis and 'Energy' on the x-axis. Two curves originate from the origin: a solid curve labeled T_2 and a dashed curve labeled T_1. The T_2 curve is higher and narrower than the T_1 curve. A vertical dashed line marks the activation energy E_a on the x-axis. A second vertical dashed line, labeled 'Catalyzed E_a', is positioned to the left of the E_a line. The area under the T_2 curve to the left of the 'Catalyzed E_a' line is shaded gray.</p> <p>curve higher AND to left of T_1 ✓ new/catalysed E_a marked AND to the left of E_a of curve T_1 ✓</p>	<p>Do not penalize curve missing a label, not passing exactly through the origin, or crossing x-axis after E_a.</p> <p>Do not award M1 if curve drawn shows significantly more/less molecules/greater/smaller area under curve than curve 1.</p> <p>Accept E_a drawn to T_1 instead of curve drawn as long as to left of marked E_a.</p>	<p>2</p>

Question			Answers	Notes	Total
4.	b		methanoic acid/HCOOH/CHOOH OR methanal/HCHO ✓	Accept "carbon dioxide/CO ₂ ".	1
4.	c	i	CH ₄ (g) + H ₂ O(g) ⇌ CH ₃ OH(l) + H ₂ (g) ✓	Accept arrow instead of equilibrium sign.	1
4.	c	ii	amount of methane = $\llcorner \frac{8.00 \text{ g}}{16.05 \text{ g mol}^{-1}} = \gg 0.498 \llcorner \text{mol} \gg \llcorner \checkmark$ amount of hydrogen = amount of methane / 0.498 $\llcorner \text{mol} \gg \llcorner \checkmark$ volume of hydrogen = $\llcorner 0.498 \text{ mol} \times 22.7 \text{ dm}^3 \text{ mol}^{-1} = \gg 11.3 \llcorner \text{dm}^3 \gg \llcorner \checkmark$	Award [3] for final correct answer. Award [2 max] for 11.4 $\llcorner \text{dm}^3$ due to rounding of mass to 16/ moles to 0.5. »	3
4.	d	i	Σ bonds broken = $4 \times 414 \llcorner \text{kJ} \gg + 2 \times 463 \llcorner \text{kJ} \gg / 2582 \llcorner \text{kJ} \gg \llcorner \checkmark$ Σ bonds formed = $1077 \llcorner \text{kJ} \gg + 3 \times 436 \llcorner \text{kJ} \gg / 2385 \llcorner \text{kJ} \gg \llcorner \checkmark$ $\Delta H \llcorner = \Sigma$ bonds broken – Σ bonds formed = $(2582 \text{ kJ} - 2385 \text{ kJ}) \gg = \llcorner + \gg 197 \llcorner \text{kJ} \gg \llcorner \checkmark$	Award [3] for final correct answer. Award [2 Max] for final answer of –197 $\llcorner \text{kJ} \gg$	3

Question			Answers	Notes	Total
4.	d	ii	$K_c = \frac{[\text{CO}][\text{H}_2]^3}{[\text{CH}_4][\text{H}_2\text{O}]} \checkmark$		1
4.	d	iii	K_c increases AND «forward» reaction endothermic \checkmark		1

Question			Answers	Notes	Total
5.	a	i	alkene ✓		1
5.	a	ii	C ₃ H ₆ ✓	<i>Accept structural formula.</i>	1
5.	b		hydrogen atoms/protons in same chemical environment ✓	<i>Accept "all H atoms/protons are equivalent". Accept "symmetrical"</i>	1
5.	c		carbon monoxide/CO AND carbon/C/soot ✓		1
5.	d		«addition» polymerization ✓		1

Question		Answers	Notes	Total
6.	a	use colorimeter OR change in colour OR change in volume OR change in pressure ✓	<i>Accept suitable instruments, e.g. pressure probe/oxygen sensor.</i>	1

Question			Answers	Notes	Total
6.	b	i	 <p>point correct ✓ straight line passing close to all points AND through origin ✓</p>	<p>Accept free hand drawn line as long as attempt to be linear and meets criteria for M2.</p>	2

Question			Answers	Notes	Total
6.	b	ii	« rate of reaction is directly» proportional to $\propto [N_2O_5]$ OR doubling concentration doubles rate ✓	<i>Do not accept "rate increases as concentration increases" / positive correlation</i> <i>Accept linear</i>	1
6.	b	iii	greater frequency of collisions «as concentration increases» OR more collisions per unit time «as concentration increases» ✓	<i>Accept "rate/chance/probability/likelihood" instead of "frequency".</i> <i>Do not accept just "more collisions".</i>	1